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Overview on different sterilization techniques for baby food



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Foreword

The nutritional quality of the product as well as other quality attributes like microbiological and sensory quality are essential factors in baby food industry, and therefore different alternative sterilizing methods for conventional heating processes are of great interest in this food sector. This report gives an overview on different sterilization techniques for baby food. The report is a part of the work done in work package 3 “QACCP Analysis Processing: Quality – driven distribution and processing chain analysis” in the Core Organic ERANET project called *Quality analysis of critical control points within the whole food chain and their impact on food quality, safety and health (QACCP)*.

The overall objective of the project is to optimise organic production and processing in order to improve food safety as well as nutritional quality and increase health promoting aspects in consumer products. The approach will be a chain analysis approach which addresses the link between farm and fork and backwards from fork to farm. The objective is to improve product related quality management in farming (towards testing food authenticity) and processing (towards food authenticity and sustainable processes).

The articles in this volume do not necessarily reflect the Core Organic ERANET’s views and in no way anticipate the Core Organic ERANET’s future policy in this area. The contents of the articles in this volume are the sole responsibility of the authors. The information contained here in, including any expression of opinion and any projection or forecast, has been obtained from sources believed by the authors to be reliable but is not guaranteed as to accuracy or completeness. The information is supplied without obligation and on the understanding that any person who acts upon it or otherwise changes his/her position in reliance thereon does so entirely at his/her own risk.

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1. Introduction

The nutritional quality of the product as well as other quality attributes like microbiological and sensory quality are essential factors in baby food industry, and therefore different alternative sterilizing methods for conventional heating processes are of great interest in this food sector. The diversity of food products, packages and related heat processes are very difficult to summarise in terms of minimum requirements. Despite the extensive knowledge in food preservation by heat treatment and despite continued attempts to improve the quality of processed food there is still a need for technologies that minimize the destructive influence of heat on valuable food compounds (Durance, 1997; Larousse&Brown, 1997; Ramesh, 1999). The need for enhancing microbial safety and quality, without compromising nutritional, functional and sensory characteristics of food has created an interest in low-temperature innovative processes for food preservation. In contrast, to the traditional thermal processes, these emerging technologies are predominantly reliant on physical processes including high pressure processing, electro-heating (radio frequency, microwave and ohmic heating), pulsed electric fields, ultrasound, microfiltration and low-temperature plasmas that inactivate micro-organisms at ambient or moderately elevated temperatures and short treatment times (Fellows, 2000). However the process must be capable of operating in a factory environment and not just in a laboratory with highly qualified staff: it should ensure a financial benefit to the manufacturer and it should be sufficiently flexible to accommodate a wide range of products, often having short production runs and brief product life cycles. The report is comparing some of the novel methods for sterilizing processes from a practical and from a processor point of view as well the practicability to use for the production of organic food..

2. General overview on sterilizing concepts

Sterilization is a process, physical or chemical, that destroys or eliminates all micro-organisms and bacterial spores. Conventional sterilization techniques rely on irreversible metabolic inactivation or on breakdown of vital structural components of the micro-organisms. Micro-organisms can be destroyed (irreversibly inactivated) by established physical microbicide treatments, such as heating, UV or ionizing radiation, by methods of new non-thermal treatments such as high hydrostatic pressure, pulsed electric fields, oscillating magnetic fields or photodynamic effects; or a combination of physical processes such as heat –high pressure or heat-irradiation. Mechanical removal of micro-organisms from food may be accomplished by membrane filtration of food liquids (Doyle et al., 2001). As a definition for sterilization is stated: *The objective of sterilization is a practical total deactivation of micro-organisms and biological substances.* (CEN-Norm 12740). Full canning sterilization process has been designed to achieve at least 12 log reductions of key spore-forming pathogens (mesophilic *Clostridium botulinum*) to achieve commercial sterility. By this process the product would be expected to remain microbiologically stable at ambient temperatures up to years (Fellows, 2000).

F –value is used as a basis for comparing heat sterilization procedures. It is a time required to achieve a specified reduction in microbial numbers at a given temperature and it thus represents the total time-temperature combination received by a food. A reference F value (F_0) is used to describe processes that operate at 121°C which are based on a micro-organism with z-value 10°C. Typical F_0 values are 3-6 min for vegetables in brine, 4-5 min for cream soups and 12-15 min for meat in gravy (Fellows, 2000).

2.1 Thermal sterilization

2.1.1 *Conventional thermal sterilization*

Thermal sterilization of canned foods is such a mature technology that it might be supposed that there is little potential for further development. Optimum thermal sterilization of food always requires a compromise between the beneficial and destructive influences of heat on the food. On the positive side, heat destroys microbial pathogens, spoilage organisms and endogenous and introduced enzymes that would otherwise render the food inedible or unsafe. However the required thermal destruction is calculated according to the slowest heating point of the food products and this causes over processing, which enhances many negative effects on the food: concentrations of heat-labile vitamins, particularly thiamine, vitamin C and folate are reduced, organoleptic quality is reduced (Durance, 1997). The texture of the canned vegetables, pasta, fish and meats is often softer than desired; canned milk products may be too brown; the surface of canned meats and other solid-packed products may be darkened by contact with the inner surface of the hot can, etc. Excess heat also has economic implications; energy consumption is a significant component of food processing costs.

However, there have been attempts for better energy utilisation, more efficient product automation, lighter, more convenient and more appealing packaging and better organoleptic quality (Durance, 1997; Fellows, 2000). In-container sterilization of fluid or semi-fluid foods can be accelerated by so-called forced convection processes in which containers are agitated by axial rotation and end-over-end rotation or other movement during the cook phase. As a result heat penetrates to the cold spot and constant mixing within the can greatly reduces overcook of the food. The classical approach to overcome or minimise undesirable quality changes in thermal processing is the high temperature short time (HTST) concept. The problem in applying the HTST principle to solid and high viscosity foods is that the parts of the food in contact with the hot surfaces will be overheated and quality losses will occur. One way to overcome this problem is by heat processing unpacked foods followed by aseptic packaging. On the whole improvements in conventional heating processes can come about only two routes; higher rates of heat transfer to critical locations in the food, or more homogenous heat distribution within the food.

2.1.2 *Electric heating methods*

Ohmic heating

Ohmic (electrical resistance) heating is a heat treatment process in which an electric current is passed through the food to achieve sterilization and desired degree of cooking. Ohmic heating is alternatively called resistance heating or direct resistance heating. The current generates heat (joule effect) in the food itself, delivering thermal energy where it is needed. Ohmic heating is a high temperature short-time method (HTST) that can heat an 80 % solids food product from room temperature to 129°C in ca. 90 seconds allowing the possibility to decrease of high temperature over processing. The control factors for commercial applications are flow rate, temperature, heating rate and holding time of the process. The factors influencing the heating in the food are the size, shape, orientation, specific heat capacity, density, and thermal and electrical conductivity, and specific heat capacity of the carrier medium (Ruan, et al., 2001). In practise the ohmic method heats particulates faster than the carrier liquid (heating inversion), which is not possible by traditional, conductive heating. Although the heating rate may be uniform, the temperature distribution across the food material can vary significantly (Quarini, 1995). Therefore design of effective ohmic heaters depends on the electrical conductivity of the food. In general e.g. fruits are

less conductive than e.g. meat samples and lean meat is more conductive than fat (Ruan, et al., 2001; Sarang et al., 2008). Commercial applications exists for ohmic heating and sterilization of solid-liquid mixtures by ohmic heating have been tested (Kemp. et al., 2007; Salengke et al., 2007).

There is a lack of proper data demonstrating the changes in major nutrients in food products and quantifying the advantages of ohmic heating. For the information according the nutrient changes in ohmic heating, one can compare the information concerning microwave heating.

From the economical point of view, ohmic heating operational costs were found to be comparable to those for freezing and retorting of low-acid products (Zoltan&Swearingen, 1996).

High frequency/radio frequency heating

High frequency heating is done in the MHz part of the electromagnetic spectrum. The frequencies of 13,56 and 27,12 MHz are set aside for industrial heating applications. Foods are heated by transmitting electromagnetic energy through the food placed between an electrode and the ground. The main advantages of RF heating compared to conventional one are improved food quality: more uniform heating, increased throughput, shorter processing lines, improved energy efficiency, improved control (heating can be controlled very precisely :switch on-switch off). Although the heating mechanism is essentially the same as with ohmic heating, RF does not require electrodes to be in contact with the food) (contactless heating). Therefore RF heating can be applied to solid as well as liquid food products. The advantage is increased power penetration. The longer wavelength at radio frequencies compared to microwave frequencies mean that RF power will penetrate further in the most products than microwave power. This can be advantage especially when thawing frozen products. There is also simpler construction than e.g. with microwave systems. Improved moisture levelling corresponds with higher quality final products.

The main disadvantages are equipment and operating costs: RF heating equipment is more expensive than conventional convection, radiation, steam heating or ohmic heating systems. Nevertheless, when factors such as increased energy efficiency and increased throughput are taken into account, the total energy cost may be comparable to a conventional system. Radio frequency heating (RF) has been used in food processing industry for many decades. In particular, RF post-baking of biscuits and cereals and RF drying of foods are well-established applications. RF pasteurization and sterilization processes are becoming more important in pre-packaged food industry (Ohlsson, T. 2002).

Microwave heating

The transfer of microwave energy to food is done by contactless wave transmission. Microwaves used in the food industry for heating are frequencies 2 450 MHz or 915 MHz corresponding to 12cm or 34cm wavelength. When a microwave is applied to a food, the water molecules of the food heat up (frictional heat created by the rapidly moving dipoles in the water). The increase in temperature of the water molecules heats surrounding components of the food by conduction and/or convection. In microwave heating less water is needed so that less extraction of valuable nutrients including minerals occur (Ehrlermann, 2002). One major limitation for industrial application of microwave heating for sterilization is the difficulty in controlling heating uniformity caused by the limited penetration depth of microwaves. The parameters important for the heating uniformity are food composition and geometry, packaging geometry and composition and applicator design (microwave energy feed system). To minimise temperature variation and also for process economy reasons, microwaves should be used in combination with conventional heating, using rapid volumetric heating for the final burst of 10-30°C to achieve HTST-like processing (Ryynänen&Ohlsson, 1996).

2.2 Non-thermal

The most extensively researched and promising nonthermal processes appear to be high pressure processing, pulsed electric fields and high intensity ultra sound combined with pressure.

2.2.1 High pressure processing

High pressure processing (HPP) is a technique where elevated pressures (up to 900 MPa with holding times varying from seconds to minutes) can be used with or without the addition of heat to preserve food without significant thermal impact on food quality. By careful selection of pressure, temperature and treatment time and use of the adiabatic temperature rise, it is possible to sterilise with high pressure. High pressure processes are also known as high hydrostatic pressure processing (HHP) and ultra high pressure processing (UHP) (Ramaswamy, 2007). HPP processing has been used with success in the chemical, ceramic and plastic industries for decades but the food industry did not recognize its potential application until the middle of 1980's.

In high pressure processing adiabatic heating results in uniform temperature rise within the product. This is a clear advantage compared to conventional heat sterilization. Currently the majority of the products are high-acid products like fruit juices, jams, jellies, salad dressing, yogurt and certain meat products. Low-acid products like shelf-stable soups are not yet commercially broadly available. In general sterilization with high pressure is possible by starting treatment at elevated temperatures e.g. 60-90 °C. In table 1 is presented some recommended high-pressure sterilization processes for certain food categories.

Table 1. Recommended high-pressure sterilization processes with two-pulse process (Meyer et al., 2000).

Food category	Initial product temperature (°C)	Pulse pressure (MPa)
Meats, pasta dishes, sauces, most vegetables	90	690
Most vegetables, whole potatoes	80	828
All vegetables, all potato products, seafood	70	1172
Eggs, milk	60	1700

The following parameters are important for the process:

- initial temperature of the product, vessel and the pressure liquid
- pressure used
- temperature during the pressure treatment
- treatment time
- number of cycles.

The quality of the high pressure sterilised products is usually superior to conventionally heat sterilised products, particularly to texture, flavour, and retention of nutrients (Matser et al., 2004). The inactivation of vegetative micro-organisms is caused by membrane damage, protein denaturation and decrease of intracellular pH. The effect of high pressure sterilization on colour is product dependent. Inactivation of vegetative micro-organisms and enzymes, combined with retention of small molecules responsible for taste and colour and many vitamins results in products with a prolonged shelf life and fresh characteristics (Matser et al., 2004). However, bacterial spores are difficult to inactivate by HPP alone and HPP must be used with other preservation methods. Inactivation of spores by combined high pressure and temperature is considered for the production of shelf-stable foods (Patterson, 2005).

Typical package is a flexible high-barrier container like a pouch or a plastic bottle. Because the pressure is transmitted uniformly and in all directions simultaneously, food product generally retains its shape even at extreme pressures. Only products containing excess air may be deformed under pressure due to difference in compressibility between the product and the air (Ramaswamy, 2007).

2.2.2 Pulse electric field (PEF)

Pulse electric field (PEF) processing involves passing a high-voltage electric field (10-80 kV/cm) through a liquid material held between two electrodes in very fast pulses typically of 1-100 μ duration. Microbial cells which are exposed to an external electrical field for a few microseconds respond by an electrical breakdown and local structural changes of the cell membrane. This leads to a loss of viability. Inactivation strongly depends on the intensity of the pulses in terms of field strength, energy and number of pulses applied on the microbial strain and on the properties of the food matrix (Toepfl et al., 2006). The main benefits of processing foods with short pulses of high electric fields are the very rapid inactivation of vegetative micro-organisms at moderate temperatures (below 40 °C or 50 °C) and with small to moderate energy requirements (50 -400 J/ml). At the moment the most successful applications are for liquid foods only and there are several limitations for the use of pulsed electric as a non-thermal technology for food preservation. Some of these limitations may be solved with product formulation (less salt, less viscous, smaller particles), improved equipment design etc. (Picart & Cheftel, 2003).

2.2.3 Ultrasonic waves

High-frequency alternating electric currents can be converted into ultrasonic waves via an ultrasonic transducer. These ultrasonic waves can be amplified and applied to liquid media by an ultrasonic probe which is immersed in the liquid or an ultrasound bath filled with the treatment liquid. The antimicrobial effect of ultrasonication is due to the cavitation which produces intense localized changes in pressure and temperature causing shear-induced breakdown of cell walls, disruption and thinning of cell membranes and DNA damage via free radical production (Earnshaw, 1998). Ultrasound used alone has been stated to be insufficient to inactivate many bacterial species and would therefore not be effective as a method for food preservation alone. However, it might have in some cases synergistic effects with other methods of food preservation like heat and pressure (Mason & Paniwnyk, 2003).

2.2.4 Electromagnetic radiation

Radiation is defined as the emission and propagation of energy through space or a material. From a food preservation point of view primary interest is in the electromagnetic spectrum. The electromagnetic spectrum contains different forms of radiation that differ in penetrating power, frequency, and wavelength; gamma radiation, ultraviolet radiation, infrared and microwaves are of special interest in the food industry (Mendonca, 2002). In this report the microwaves are discussed in chapter dealing with electric heating methods.

Irradiation

Irradiation of bulk or prepacked foods is achieved by exposing the product to a source of ionizing energy typically Cobalt-60 (Wood&Bruhn, 2000). Irradiation is not allowed in organic food processing and its use as a preservation method of conventional products is restricted in EU (mainly allowed only for spices, in Netherlands, France and Spain for frozen fish, poultry).

Ultraviolet Light/Radiation

Disinfection by ultraviolet radiation is a physical process defined by the transfer of electromagnetic energy from a light source to an organism's genetic cellular material. The lethal effects of this energy are the cell's inability to replicate. The effectiveness of the radiation is a direct function of the quantity of energy (dose) that was absorbed by the organism.

Short-wave ultraviolet light (UVC) is reported to be an effective method for inactivating bacteria on surfaces of food and on liquids like fruit and vegetable juices (Sastry et al., 2000, Bintsis et al. 2000). Short-wave ultraviolet light has very low penetrability into solid materials (Shama,1999). Therefore UVC treatment may be effective for disinfecting surfaces. Short-wave ultraviolet irradiation can be used to treat food surfaces. It has been used to control *Bacillus stearothermophilus* growth in thin layers of sugar (Weiser, 1962). Other applications of UVC irradiation of food surfaces have been reported by Huang and Toledo (1982) for fresh fish, Kuo et al. (1997) for egg shells, Reagan et al. (1973) and Stermer et al. (1987) for beef, Wallner-Pendleton et al. (1994) for poultry carcasses, and Lee et al. (1989) for chocolate.

An important factor influencing the efficacy of UV treatment is the form in which the liquid makes contact with UV radiation. Because of the viscosity of most liquids containing solids (sugars, salt, starch, and other solids), the flow will be laminar, which requires a different design from a typical water unit designed to produce turbulent flow. Short-wave ultraviolet irradiation application to eliminate pathogens from fruit juices depends on ensuring that the flow of the juice is turbulent rather than laminar (Anonymous, 1999; Bintsis et al., 2000).

The benefits of UV in comparison to other methods of disinfection are that no chemicals are used; it is a non-heat-related process; there is no change in colour, flavour, odour, or pH; and no residuals are left in the fluid stream. It is evident that the food industry is viewing UVC-technology with special interest since there is a need to produce microbiologically safe foods while improving retention of natural flavour, colour, and appearance (Bintsis et al., 2000). One technological innovation in ascendancy is the use of UV-light for juice pasteurization (Hollingsworth, 2001); several companies are evaluating and testing UV-treatments as an alternative to pasteurizing fruit and vegetable juices, as well as other fluid products.

Infrared

Infrared (IR) waves occupy that part of the electromagnetic spectrum with frequency beyond that of visible light. In contact with material, the IR waves are either reflected, transmitted or absorbed. Absorbed waves are transformed into heat and the temperature of the material increases. The main commercial applications of IR heating are drying low moisture foods such as breadcrumbs, coca, flour, grains, malt and tea. It is also used as an initial heating stage to speed up the initial increase in surface temperature.

2.2.5 *Other methods*

Shaka –system

The process is based on the rapid agitation of canned or other types of packaged foods in a specially built retort or autoclave used during sterilization. The process could be potential for processing low to medium viscous products like soups, sauces and some ready meals. Cooking times for foods can be lowered by up to 95 % for canned food and ca. 90 % for many flexible pack products and up to 80 % for products in glass jars. (El Amin, 2005.)

In table 2 is presented a sum up of different sterilization methods and reviewed the industrial relevance, advantages and disadvantages of the method.

Table 2. Different sterilization methods allocated as thermal and non-thermal methods.

Method	Industrial relevance	Advantage	Disadvantage
THERMAL			
Conventional heat treatment in autoclave/ retort	Covers almost all food product groups	<ul style="list-style-type: none"> ■ Direct energy transport to the product (steam) ■ Well established technology ■ High food safety 	<ul style="list-style-type: none"> ■ High heat load for the product causing structural and nutritional defects ■ Energy consuming
Ohmic heating	Covers almost all food product groups	<ul style="list-style-type: none"> ■ Generates the heat in the food itself, delivering thermal energy where it is needed. ■ Particulate temperatures similar or higher than liquid temperatures ■ Faster than conventional heat processing ■ Minimal mechanical damage to the product and better nutrients and vitamin retention ■ High energy efficiency because 90 % of the electrical energy is converted into heat ■ Ease of process control with instant switch-on shut-down 	<ul style="list-style-type: none"> ■ Lack of temperature monitoring techniques in continuous systems ■ Differences on electrical conductivity between solids and liquid ■ Lack of data concerning the critical factors affecting heating
High frequency/ Radio frequencyMicrowave		<ul style="list-style-type: none"> ■ Direct energy transfer into the food ■ No structural damages to food ■ Improved food quality: more uniform heating ■ increased throughput ■ Shorter processing lines ■ Improved energy efficiency ■ Maillard reactions may be reduced 	<ul style="list-style-type: none"> ■ Technology is in a early stage of the development ■ High energy consumption ■ Not compatible with organic
NON-THERMAL			
High pressure	<p>High-acid products</p> <p>like juices, jams, jellies and yoghurts</p> <p>Pasteurization of meats and vegetables</p>	<ul style="list-style-type: none"> ■ Texture, taste and retention of nutrients are better than for conventional retort. ■ Shorter treatment times ■ Lower maximum temperature ■ Faster heating and cooling ■ More uniform temperature rise within the product ■ In principal independent of the size, shape and composition of the food product ■ No evidence of toxicity 	<ul style="list-style-type: none"> ■ Not yet commercial application for shelf-stable low-acid products ■ Energy consuming ■ Expensive equipment ■ Food should have ca. 40 % of free water for anti-microbial effect ■ Limited packaging options ■ Regulatory issues to be resolved

Pulse-electric field	Liquid foods fruits juices, soups liquid egg and milk Accelerated thawing	<ul style="list-style-type: none"> ■ Kills vegetative cells ■ Colours, flavours and nutrients are preserved ■ No evidence of toxicity ■ Relative short treatment time 	<ul style="list-style-type: none"> ■ Difficult to use with conductive materials ■ Only suitable with liquids or particles in liquids ■ Energy efficiency not yet certain ■ No effect on enzymes and spores
Ultrasonic waves	Any food that is heated	<ul style="list-style-type: none"> ■ Effective against vegetative cells, spores and enzymes ■ Reduction of process times and temperatures 	<ul style="list-style-type: none"> ■ Can denature proteins and produce free radicals which can affect the flavour (high fat foods)
Microbiocide gas for example ethylene oxide, ethanol, ozone			<ul style="list-style-type: none"> ■ Not accepted in EU at all for food ■ Not compatible with organic foods ■ Only for specific foods useful ■ Expensive
Irradiation	Covers almost all food product groups	<ul style="list-style-type: none"> ■ Pre-packed products can be processed 	<ul style="list-style-type: none"> ■ Not accepted in EU at all for food ■ Not compatible with organic food
Ultra-violet	Dry foods Fresh fruit and vegetables	<ul style="list-style-type: none"> ■ Medium cost ■ Rapid process ■ Little or no changes in food 	<ul style="list-style-type: none"> ■ Possible adverse chemical effects ■ Not proven effective against spores ■ Only surface effects (problems with complex surfaces)
Infrared	Low moisture foods		

2.3 Combined technologies

Many of the novel nonthermal processes require very high treatment intensities, however, to achieve adequate microbial destruction in low-acid foods. Combining nonthermal processes with conventional processing methods enhances their antimicrobial effect so that lower process intensities can be used. Combining two or more nonthermal processes can also enhance microbial inactivation and allow the use of lower individual treatment intensities. For conventional preservation treatments, optimal microbial control is achieved through the hurdle concept, with synergistic effects resulting from different components of the microbial cell being targeted simultaneously (Ross et al., 2003). However, the intelligent application of a hurdle technology requires knowledge of the mechanism of each hurdle applied (Leistner, 2000) and in this area the knowledge of nonthermal technology is most lacking.

Some successful combination treatments are HPP with temperature combination, HPP with chemical agents, and oscillatory pressure cycle treatments. A treatment that first germinates the spores and then inactivates the outgrowing cells could reduce processing intensity. However the benefit of a combined pressure-temperature treatment is progressively impaired with increasing temperature. In table 3 is presented main combinations including nonthermal methods of food preservation.

Table 3. *Main combinations that include nonthermal methods of food preservation investigated and objectives reached with these combinations (Raso&Barbosa-Canovas, 2003)*

	Heat	Low pH	Low temperature	Antimicrobials	Modified atmosphere	Carbon dioxide	High hydrostatic pressure
High hydrostatic pressure	+▼	+▼●	●	+▼●	●	+▼	
Ultrasonic waves	+▼						
Pulsed electric field	+▼	+▼●	●	+▼●			+▼
Irradiation	+▼		●		●		+▼

+ Increases the lethality of nonthermal process

▼ Decreases treatment intensity of nonthermal process

● Inhibition of microbial growth after treatment

HHP and PEF are gaining commercial application most rapidly with juices and other fruit-derived products as the hurdle of low pH exists naturally in the raw material. More research is needed before these technologies can be adapted for the production of shelf-stable low acid foods (Raso & Barbosa-Canovas, 2003).

The addition of naturally occurring antimicrobials has proven to be an effective hurdle when combined with HHP and PEF. Nisin is currently the only bacteriocin approved for use in food by the WHO. Aside the regulatory control, the use of natural antimicrobials in commercial food supplies is also restricted by high costs and inhibition of their bactericidal activity in complex food substrates. Two most studied natural antimicrobial compounds are nisin and lysozyme (Smid & Garris, 1999).

3. Discussion

Sterilizing methods for baby food – advantages and disadvantages

For baby food the microbiological safety is a very important factor. Young children are sensitive towards micro-organisms. Even the exception of the parents is to by “absolutely” safe food. Theoretically this strong approach for baby food used after the 4th or 5th month can be questioned. Practical it is not possible because of the legal requirements and the consumer perception. No company producing baby food can survive if they do not fulfil the very highest hygienic standards. If products are produced in heat preserved way the “heat load” is the limiting quality factor. If the product must to be sterilized the influence of “heat load” to the product quality is tremendous. Some criterias for selecting the optimal sterilization method or technique for organic baby food are presented in appendix 1.

Theoretical even other preservation techniques are possible:

1. For example products can be presented as dehydrated product to the consumers. If this can be produced with the help of freeze dehydrating techniques the product quality will be relatively good protected. The problems here are the energy costs for doing so. Further on it is not sure that consumers will accept such products.
2. A more realistic concept would be to present the baby food products as deep frozen products. The technique is available the costs are realistic and the consumers learned in the last years that the quality of deep frozen products are better than can food. From the quality perspective deep frozen products are in terms of vitamins and so on better than canned food. Explicitly if the product will not be stored to long.
3. There are different possibilities beside or combined with autoclaves to available to sterilize or pasteurize canned food. A number of those techniques as ionizing irradiation or the use of preservatives is not acceptable for organic baby food.
4. In terms of working with autoclaves one method seems practical available. To work with shaka methods means to bring the caned food inside the can to move in order to improve the heat transport inside the product. By doing so the sterilization time will be shortened and the heat load reduced.
5. Microwave and other energetic waves could even be used to bring energy more direct and therefore faster into the canned foods. The problem with this technique is today the high energy consumption, the unequal energy distribution. Further on there is a question if such methods will be accepted by the organic consumers. For example there are a lot of concerns toward microwave in the organic sector.
6. Theoretically a total new concept could be established. To change from a discontinuous process with autoclaves to a continues concept with aseptic packaging opens a lot of new technological opportunities which seems to be positive for the quality.

By producing a relatively fluid baby food which will be prepared in a first step with microfiltration. Afterwards the good will be treated with high pressure applications (or thin layer heat based sterilization, steam injection or energetic waves) for the “total” reduction of MO. The next step is aseptic packaging (canned). The product could be prepared with thickeners which works after a while or which needs to be activated during warming up for consumption.

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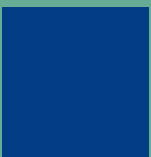
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Appendix 1. Some criterias for selecting optimal sterilization method for organic baby food.

Sterilization method	Food safety affecting factors	Product range	Nutritional influence	Sensory quality	Packaging
Autoclave	Inactivates microbes and the bacterial spores.	Covers almost all food product groups.	Causes nutritional defects.	Causes structural, taste and colour defects.	Glass jars, cans, retort pouches.
Ohmic heating	Lack of temperature monitoring techniques in continuous systems.	Covers almost all food product groups.	Better nutrient and vitamin retention than in conventional heating systems. Comparable to microwave heating.	Minimal mechanical damage to the product.	Flexible high barrier packages like pouches and plastic bottles.
High frequency/ Radio frequency	Heating can be controlled very precisely.	Pre-packed foods, both solid and liquid.	No data.	No data.	Flexible high barrier packages.
Microwave	Difficulties for controlling heating uniformity.	Pre-packed foods, both solid and liquid.	No data.	No data.	Flexible high barrier packages.
High pressure	Bacterial spores difficult to inactivate by high pressure alone. Food should have 40 % of free water for antimicrobial effect. No evidence of toxicity	High acid products like juices, jams, jellies and salad dressings, yogurt, certain meat products	Better nutrient and vitamin retention than in conventional heating systems.	Better texture and taste than in conventional heating systems Effect on colour product dependent.	Flexible high barrier packages like pouches and plastic bottles
Pulse electric fields	No evidence of toxicity. Kills vegetative cells but no effect on enzymes and spores.	Liquid products like fruit juices, soups and milk	Nutrients are preserved better than in conventional heating.	Better colour and flavour than in conventional heating.	Flexible high barrier packages like pouches and plastic bottles
Ultrasonic waves	Insufficient to inactivate many bacterial species alone. Causes DNA-damage to bacteria cells.	Any food that is heated.	No data.	Flavour defects with high fat foods.	Flexible high barrier packages.
Irradiation	Restricted use in EU for food and not compatible in organic foods.	Prepacked foods	No data.	Flavour defects, especially high fat foods.	All kind of packages.
Ultraviolet light	Possible adverse chemical affects. Not proven effective against spores.	Fresh fruit and vegetables, dry foods.	No data.	No data.	Flexible high barrier packages.
Infrared	No data.	Low moisture foods	No data.	No data.	Flexible high barrier packages.
Shaka-system	No data.	Low to medium viscous products like soups and sauces.	No data but 80-95% shorter cooking times may improve the quality compared to conventional heating.	No data but 80-95% shorter cooking times may improve the quality compared to conventional heating.	Cans and other packages for autoclave or retort.



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